REMARKS

This amendment is responsive to the Office Action of October 10, 2006. Reconsideration and allowance of claims 19-33 are requested.

The Office Action

Claims 1, 3-5, 10-12, and 15-17 stand rejected under 35 U.S.C. § 102 as being anticipated by Zhang (US 5,652,514).

Claims 1, 2, and 8 stand rejected under 35 U.S.C. § 102 as being anticipated by Schaeffer (US 2002/0048340).

Claims 6, 7, 9, 13, 14, 17, and 18 stand rejected under 35 U.S.C. § 103 as being unpatentable over Zhang (US 5,652,514) in view of Yao (US 4,885,542).

Objections to the Drawings and Specification

The applicants are submitting new drawings of Figures 3 and 4 in which the extra "Δf" has been deleted.

As the Examiner assumed, "TR" is indicative of repetition time. However, the noted paragraphs on pages 5 and 6 have been amended to change "TR" to "repetition" which is better axiomatic English.

The original claims have been cancelled, obviating the Examiner's objection to claims 11-14. Where applicable in the new claims, the applicants have used language proposed by the Examiner.

The References of Record

Zhang and Schaeffer correct the acquired data for a given image from the acquired data for the given image itself. Since the data for correcting an image is not available until the image data is collected, Zhang and Schaeffer are directed to ***retrospective*** corrections. The present application focuses on a ***prospective*** technique in which information from two preceding data sets are used to adjust scan parameters for generation of a subsequent data set.

Zhang is directed to an imaging sequence in which a steady-state spin precession is established. Periodically during the acquisition of image data, e.g., every 16 lines (column 7, line 35), a zero k-space line (field line) is acquired.

The phase-shift between these zero k-space lines is determined and interpolated across the entire data set (column 6, lines 37-47). With the example of the zero k-space data line occurring every 16 image lines, the correction is interpolated for the 15 intervening data lines. In this manner, the acquired image data is ***retrospectively*** corrected after data acquisition.

Thus, Zhang is directed to a data correction process in which data of an image data set is corrected based on concurrently collected data in the same data set. There is no disclosure how one might apply the Zhang technique to a prospective technique which alters the excitation frequency or magnetic field strength correction for subsequent data acquisition. Indeed, because a zero k-space line is applied at the beginning and ***end*** of each 16 image lines and interpolated to determine the correction for the intervening lines, ***the correction cannot be determined until after the data is acquired.***

Schaeffer relates to an EPI imaging method in which k-space data lines are acquired in which the phase is encoded for one set of data lines using positive phase-encode pulses and another set of data lines is acquired using negative polarity phase-encode pulses. More specifically, phase-encode pulses of the same magnitude, but opposite polarity, are used to collect analogous data lines. By comparing the actual phase of these analogous data lines with the same magnitude but opposite polarity phase-encoding, a phase-error can be determined. This determination can only be made ***after the corresponding positive and negative polarity phase-encoded steps or image lines have been collected.***

Schaeffer also determines the phase error corrections using the actual image data, hence Schaeffer can only be utilized after the data is collected. There is no disclosure in Schaeffer as to how one could use the technique ***prospectively*** to adjust resonance frequency or magnetic field strength for future data acquisitions. After the data has been collected, it is too late to make an excitation frequency or magnetic field magnitude adjustment to correct those two data lines.

Yao was filed at a time when less stable resistive magnetic resonance magnets were common. Yao indicates that a drift of 100 Hz can shift positions along z-axis by 10% and positions along an x-axis by 5%. Yao further indicates that cryomagnets, which were less common in 1988 than today, are more stable and may

drift only 20 Hz over an entire day. To address this problem, Yao proposes a correction template that provides the calibration for each slice. Yao also recognizes that when an image line is acquired with no phase-encoding, it is effectively a measure of the position of the center of the slice (column 7, lines 38-50). To prevent the data of a multi-slice image from "sliding" over the period of time in which the data is acquired, Yao proposes adjusting the magnetic resonance frequency or the field strength.

The Claims Distinguish Patentably
Over the References of Record

Claim 19 is directed to a single shot EPI imaging technique. Zhang is directed to a steady-state spin precession technique rather than a single shot EPI technique. Although Schaeffer discloses an EPI technique, the Schaeffer technique calls for a plurality of interleaved EPI sequences for generating an image and the data to correct such image data and Schaeffer is not directed to a single shot technique. Indeed, the repetition of phase-encoding steps with different polarity gradients in subsequent repetitions is a key element of the Schaeffer technique. Thus, the techniques of the references of record would need serious adaptation and further inventive effort in order to adapt them to single shot EPI imaging.

Second claim 19 calls for the data acquisition of the zero phase-encode data line to be acquired at the same time interval after excitation in two single shot EPI sequences. The references of record note that eddy currents caused by the application of gradients are a factor which causes phase-shifts. However, none of these references recognize or fairly suggest sampling for phase correction at the ***same time interval*** after excitation in subsequent sequences. To the contrary, Zhang distributes zero phase-encode data lines throughout the steady-state spin precession sequence, e.g., every 16 lines. Similarly, Schaeffer generates data lines for comparison throughout the imaging sequence. Yao uses a template which collects calibration data lines before and after an imaging sequence. Indeed, Schaeffer and Zhang are looking to collect calibration data during the image data collection to use retrospectively to correct the self-same image data that was just corrected. This same time interval limitation in claim 19, that is not met by the references, enables it to function in a different way to perform a different function.

Finally, claim 19 calls for using the determined phase difference to correct the excitation frequency or the main magnetic field magnitude. The Zhang technique, like the Schaeffer technique, is looking to correct the image data within which the calibration data is periodically sampled. Zhang is directed to a retrospective correction technique; whereas, claim 19 is directed to a prospective technique. Moreover, Zhang samples the zero phase-encode data lines multiple times, e.g., every 16 lines, during imaging, and interpolates the shifting phase during the image to create a phase correction for every data line. When one uses single-shot EPI sequences, one can collect an entire slice of data after the single excitation. Comparing the same data line each of two single-shot EPI sequences can be used to change imaging conditions or parameters for a next yet-to-be-conducted sequence. Schaeffer also determines a phase-shift correction for each data line. It is submitted that there is no motivation to try to adapt or reinvent such a technique for prospective corrections.

Accordingly, it is submitted that **claim 19 and claims 20-22 dependent therefrom** distinguish patentably and unobviously over the references of record.

Claim 23 is directed to a gradient echo sequence. By contrast, Zhang is directed to a steady-state spin precession sequence; Schaeffer is directed to an interleaved EPI sequence; and Yao calls for a spin-echo technique (column 6, lines 1-2).

Further, claim 23 calls for the first and second phases to be measured the same preselected time after excitation. This concept is missing from the applied references. Zhang applies the calibration phase-encoding periodically, e.g., every 16 image lines, during data acquisition and interpolates the phase-shift therebetween. This interpolated phase-shift error is used to correct the intervening image lines. Thus, there is no recognition of any need or requirement for a set time interval between initial excitation and the collection of the data used for phase correction. Schaeffer uses all data lines, more specifically, the equal magnitude opposite polarity phase-encoded data lines, to determine phase corrections for themselves. Schaeffer imposes no requirement that zero phase-encode lines be collected any specific time interval after excitation, much less suggests matching that time interval to the corresponding time interval in a different sequence. Yao uses a calibration template

which applies calibration pulses and measurements in a template. None of the references recognize the significance of making the calibration measurement the same time interval after the excitation in each of plural sequences.

Accordingly, it is submitted that **claim 23 and claims 24-31 dependent therefrom** distinguish patentably and unobviously over the references of record.

Claim 32 calls for the calibration data line to be collected at preselected interval following each excitation. In the Zhang technique, the duration after excitation that the calibration data lines are measured is not significant. Schaeffer compares the phase of like magnitude opposite polarity image lines and has no recognition of collecting such like magnitude data lines at a common time after excitation in each sequence. Yao applies a calibration template with a calibration sequence before and after each set of imaging data.

Accordingly, it is submitted that **claim 32 and claim 33 dependent therefrom** distinguish patentably and unobviously over the references of record.

CONCLUSION

For the reasons set forth above, it is submitted that claims 19-33 (all claims) distinguish patentably over the references of record and meet all statutory requirements. An early allowance of all claims is requested.

In the event the Examiner considers personal contact advantageous to the disposition of this case, she is requested to telephone Thomas Kocovsky at (216) 861-5582.

Respectfully submitted,

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